

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 7,175,599 B2  
APPLICATION NO. : 10/822181  
DATED : February 13, 2007  
INVENTOR(S) : Kullervo Hynynen et al.

Page 1 of 20

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

The title page should be deleted to appear as per attached title page.

The sheets of drawings consisting of figures 1-26 should be deleted to appear as per attached figures 1-26.

Signed and Sealed this

Sixteenth Day of February, 2010

A handwritten signature in black ink that reads "David J. Kappos". The signature is written in a cursive, flowing style with a large, stylized 'D' and 'K'.

David J. Kappos  
*Director of the United States Patent and Trademark Office*

(12) **United States Patent**  
**Hynynen et al.**

(10) **Patent No.:** **US 7,175,599 B2**  
(45) **Date of Patent:** **Feb. 13, 2007**

(54) **SHEAR MODE DIAGNOSTIC ULTRASOUND**

(75) Inventors: **Kullervo Hynynen**, Medfield, MA  
(US); **Gregory T. Clement**, Boston,  
MA (US)

(73) Assignee: **Brigham and Women's Hospital, Inc.**,  
Boston, MA (US)

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 315 days.

(21) Appl. No.: **10/822,181**

(22) Filed: **Apr. 9, 2004**

(65) **Prior Publication Data**  
US 2004/0210135 A1 Oct. 21, 2004

**Related U.S. Application Data**  
(60) Provisional application No. 60/463,589, filed on Apr.  
17, 2003.

(51) **Int. Cl.**  
**A61B 8/00** (2006.01)

(52) **U.S. Cl.** ..... **600/443**

(58) **Field of Classification Search** ..... 600/438,  
600/440 441, 443, 447, 449 450; 73/625 626  
See application file for complete search history.

(56) **References Cited**

#### U.S. PATENT DOCUMENTS

3,996,792 A \* 12/1976 Kubota et al. .... 73/611  
4,221,132 A \* 9/1980 Poole ..... 73/620  
4,789,969 A \* 12/1988 Naville ..... 367/36  
4,817,614 A \* 4/1989 Hassler et al. .... 128/660.05  
5,197,475 A \* 3/1993 Antich et al. .... 600/437

5,426,979 A \* 6/1995 Kantorovich et al. .... 73/628  
5,606,971 A \* 3/1997 Sarvazyan ..... 128/660.02  
5,752,515 A \* 5/1998 Jolesz et al. .... 128/653.1  
5,810,731 A \* 9/1998 Sarvazyan et al. .... 600/438  
6,135,960 A \* 10/2000 Holmberg ..... 600/447  
6,561,981 B2 \* 5/2003 Bonnefous ..... 600/443  
6,585,647 B1 \* 7/2003 Winder ..... 600/437  
6,638,219 B1 \* 10/2003 Asch et al. .... 600/437  
6,764,448 B2 \* 7/2004 Trahey et al. .... 600/437  
6,770,033 B1 \* 8/2004 Fink et al. .... 600/443

(Continued)

#### FOREIGN PATENT DOCUMENTS

WO WO 99/56829 11/1999

(Continued)

#### OTHER PUBLICATIONS

International Search Report for PCT/US2004/011374, mailing date:  
Jul. 21, 2004.

(Continued)

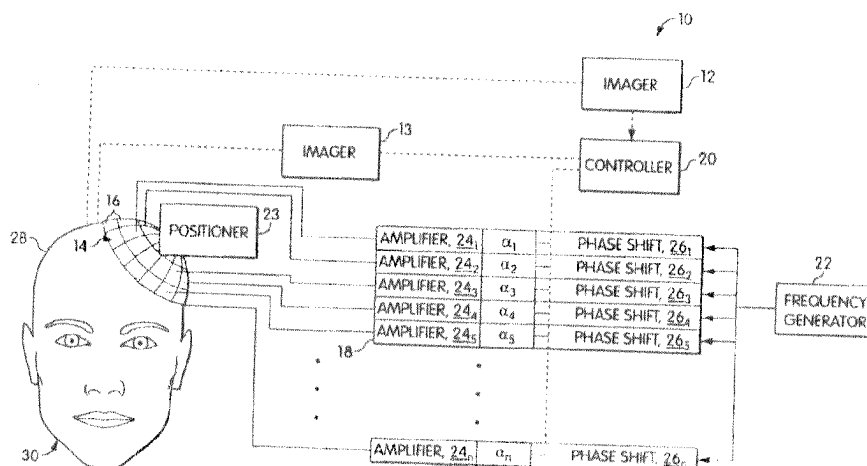
*Primary Examiner*—Francis J. Jaworski

(74) *Attorney, Agent, or Firm*—Shane H. Hunter; Mintz,  
Levin, Cohn, Ferris, Glovsky and Popeo, P.C.

(57) **ABSTRACT**

A method of diagnosing a subject by delivering ultrasound  
signals using shear waves includes applying a portion of an  
ultrasound mainbeam to a bone surface at an incident angle  
relative to the surface of the bone to induce shear waves in  
the bone, energy in the shear waves forming a substantial  
part of energy of first ultrasound waves at a desired region  
in the subject through the bone, detecting at least one of  
reflected and scattered energy of the applied ultrasound  
mainbeam, and analyzing the detected energy for a diag-  
nostic purpose.

**46 Claims, 23 Drawing Sheets**



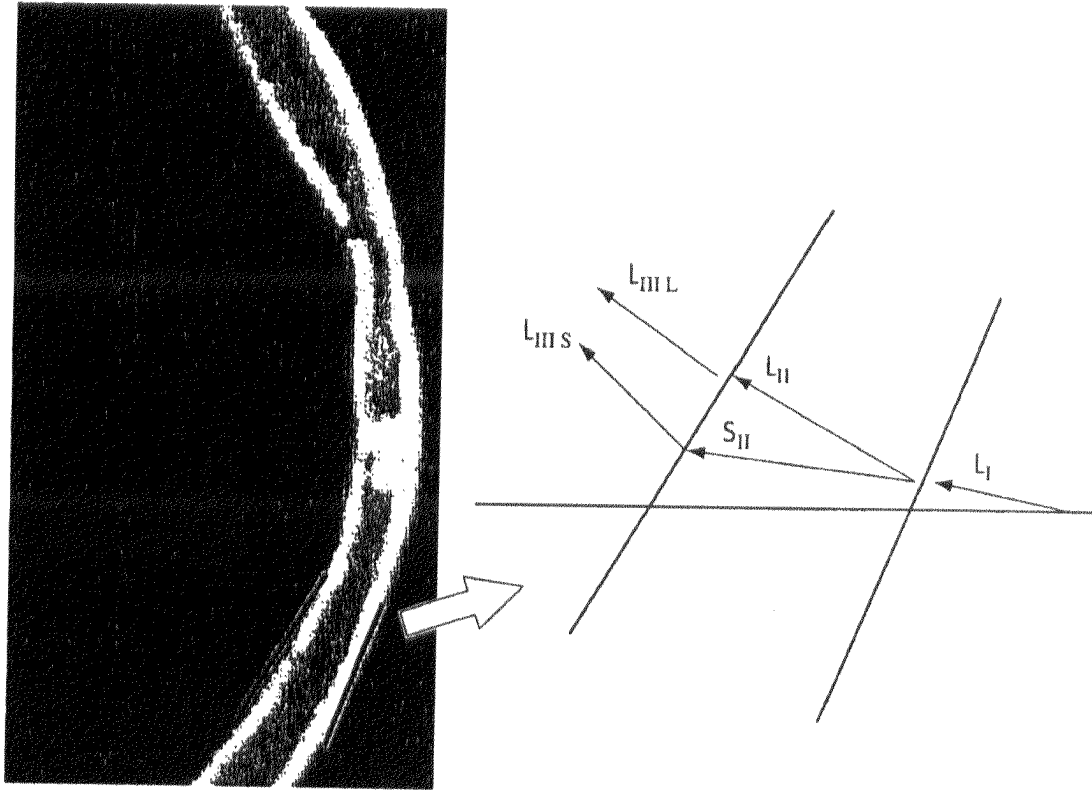


Fig. 1

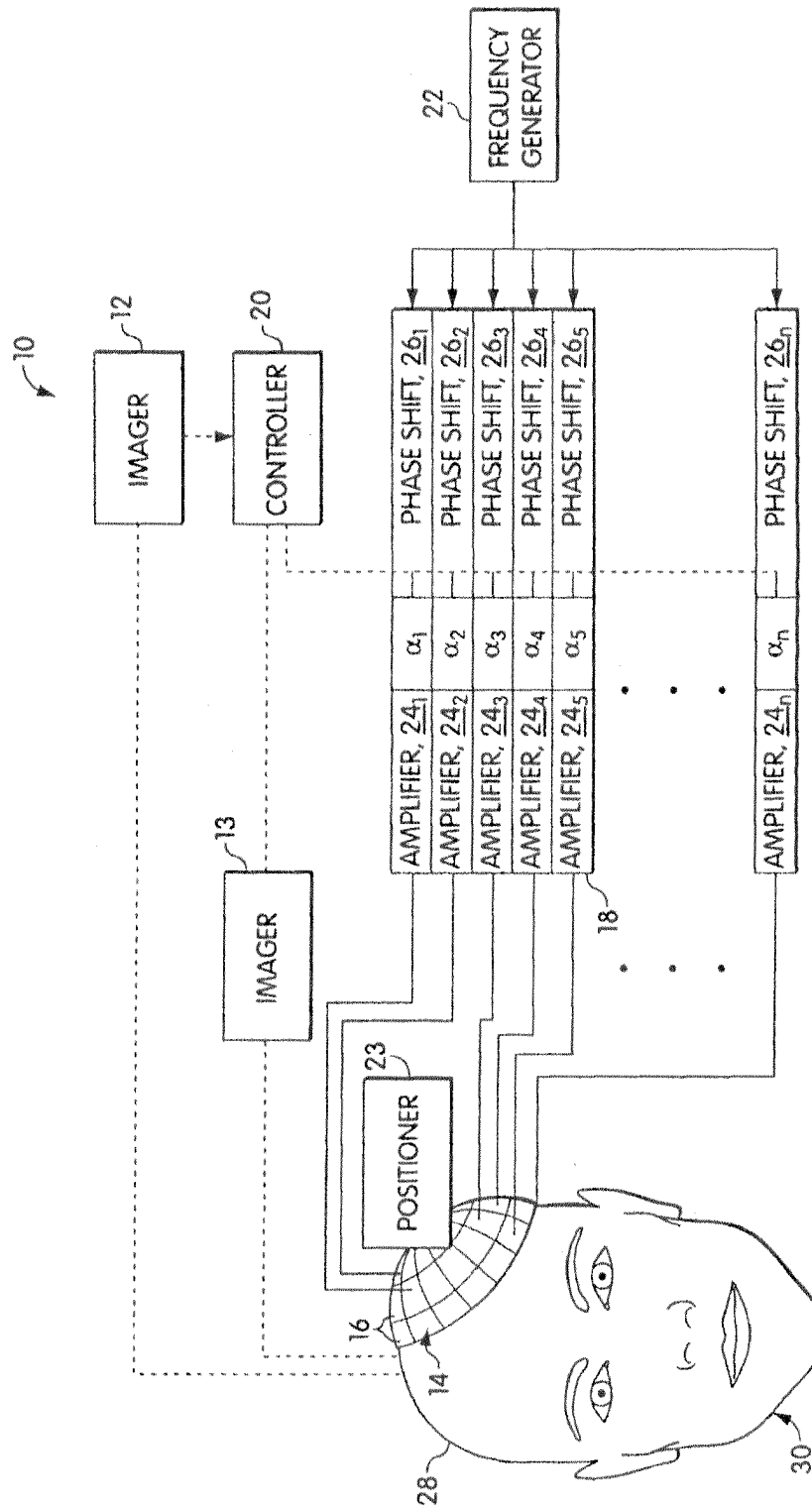


Fig. 2

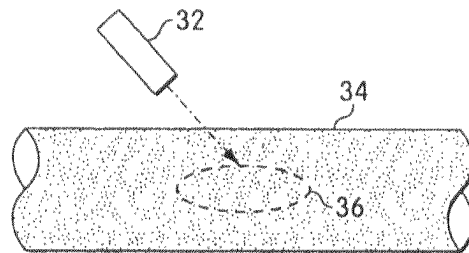


Fig. 3

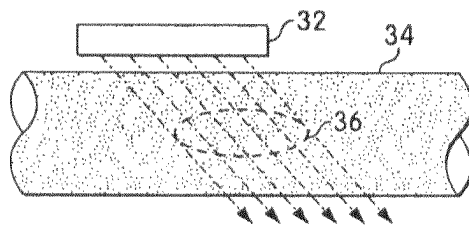


Fig. 4

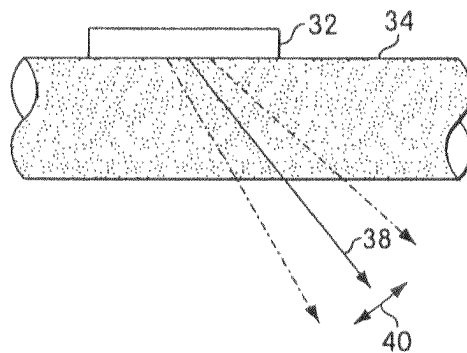


Fig. 5

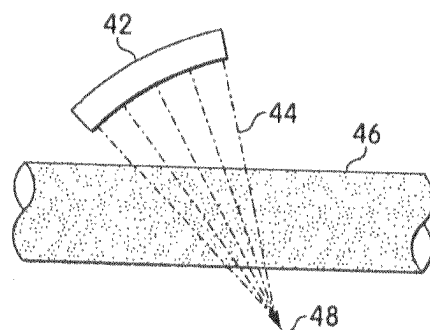


Fig. 6

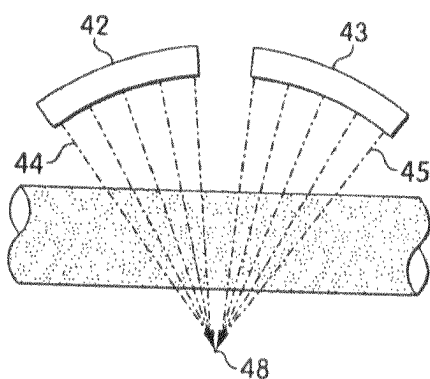


Fig. 7

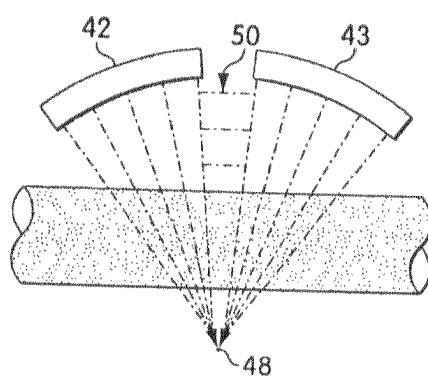


Fig. 8

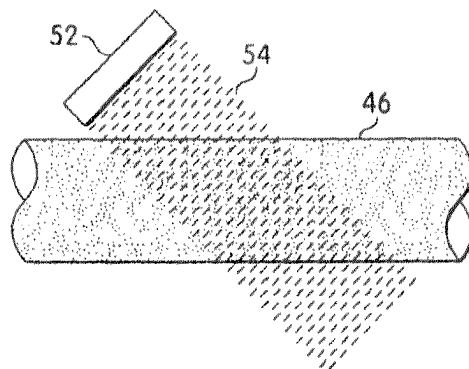


Fig. 9

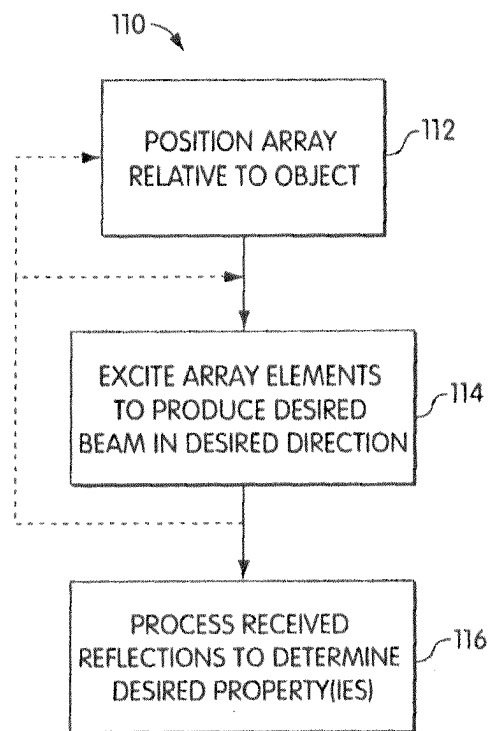


Fig. 10

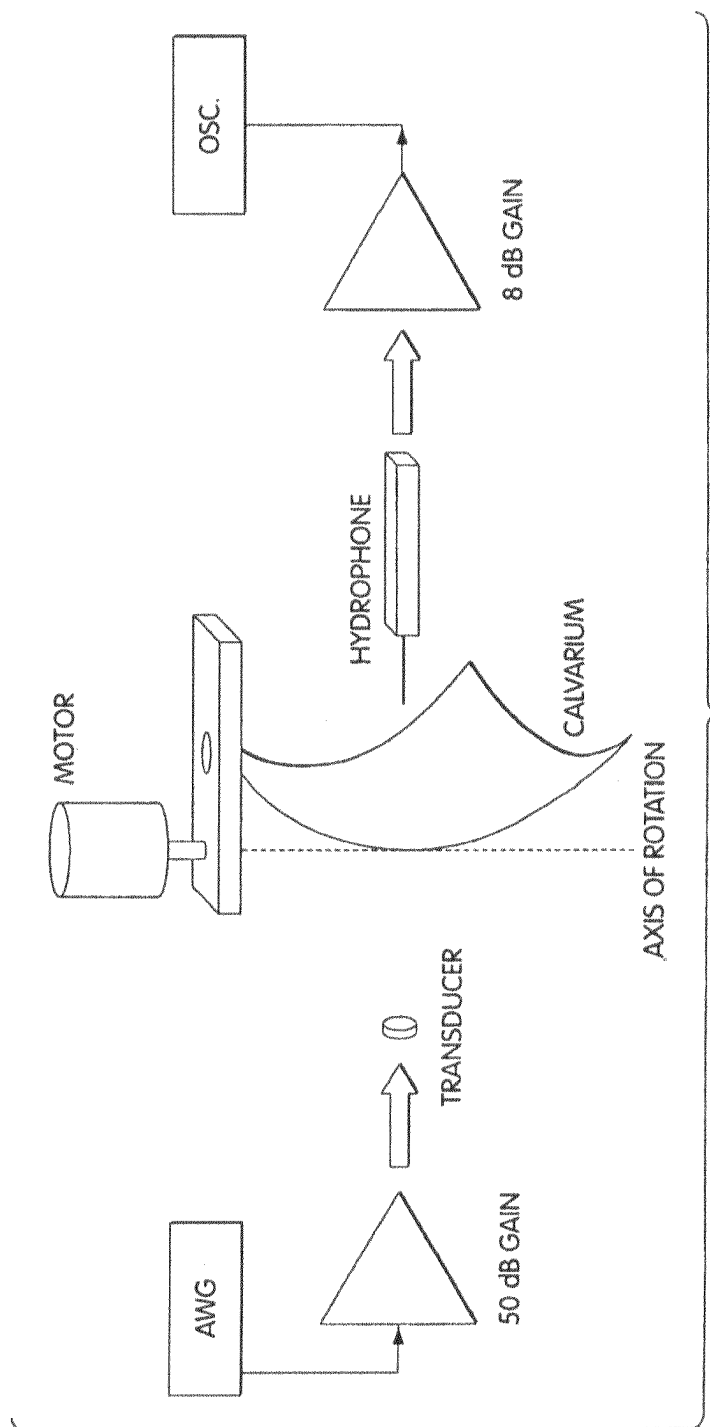


Fig. 11



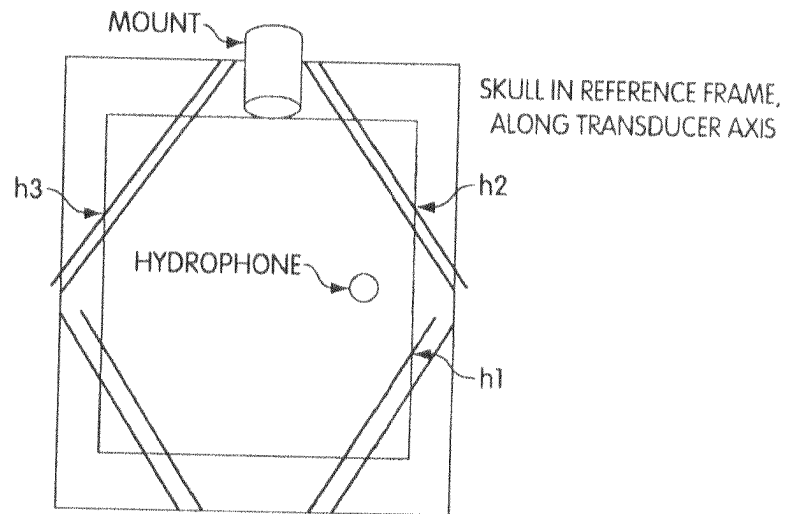


Fig. 12

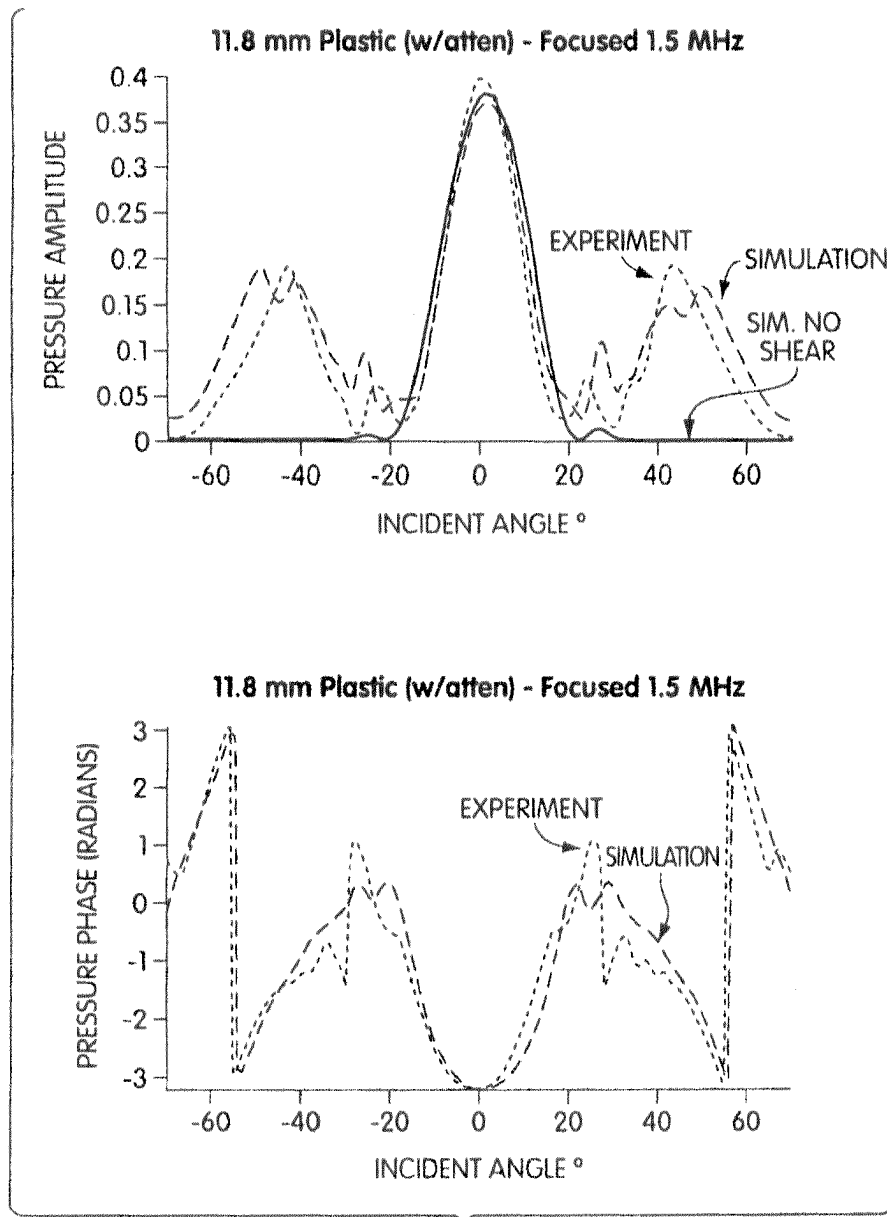


Fig. 13

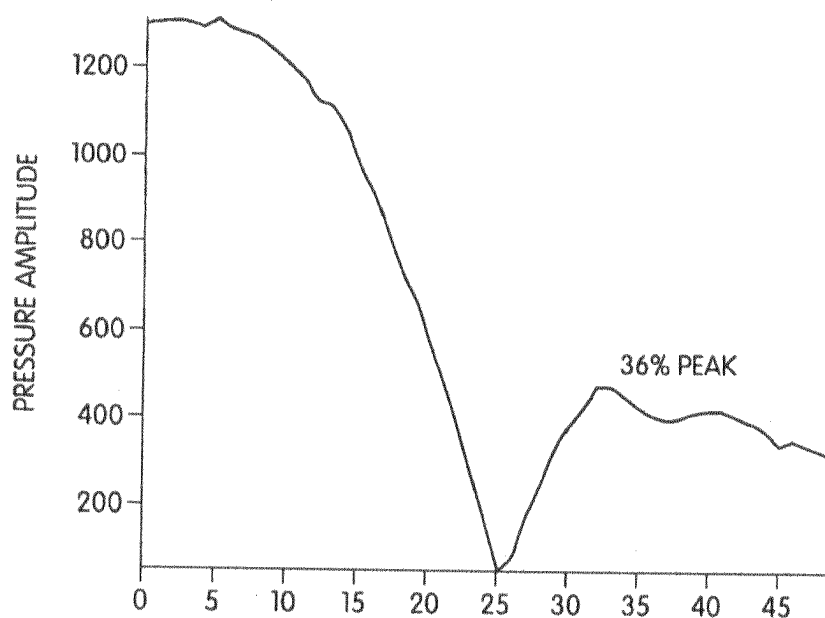


Fig. 14A

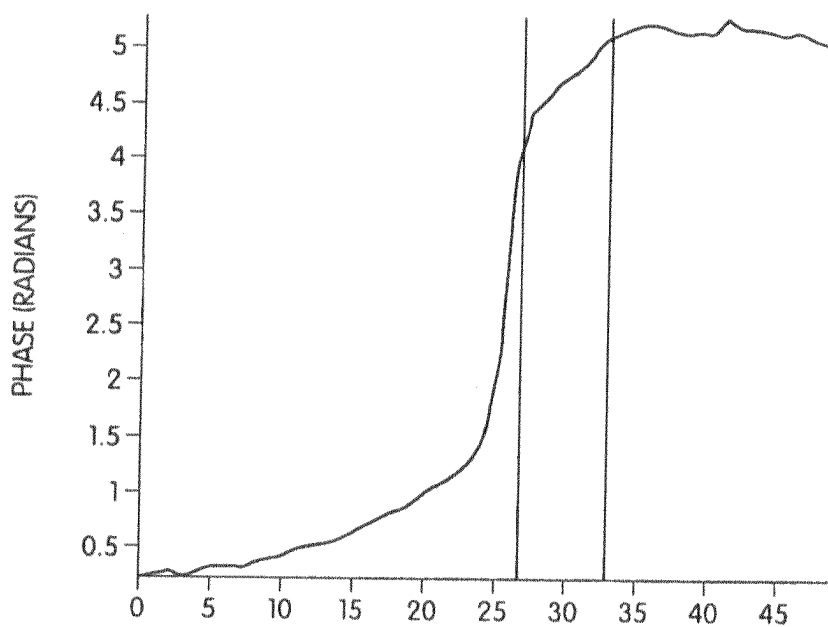
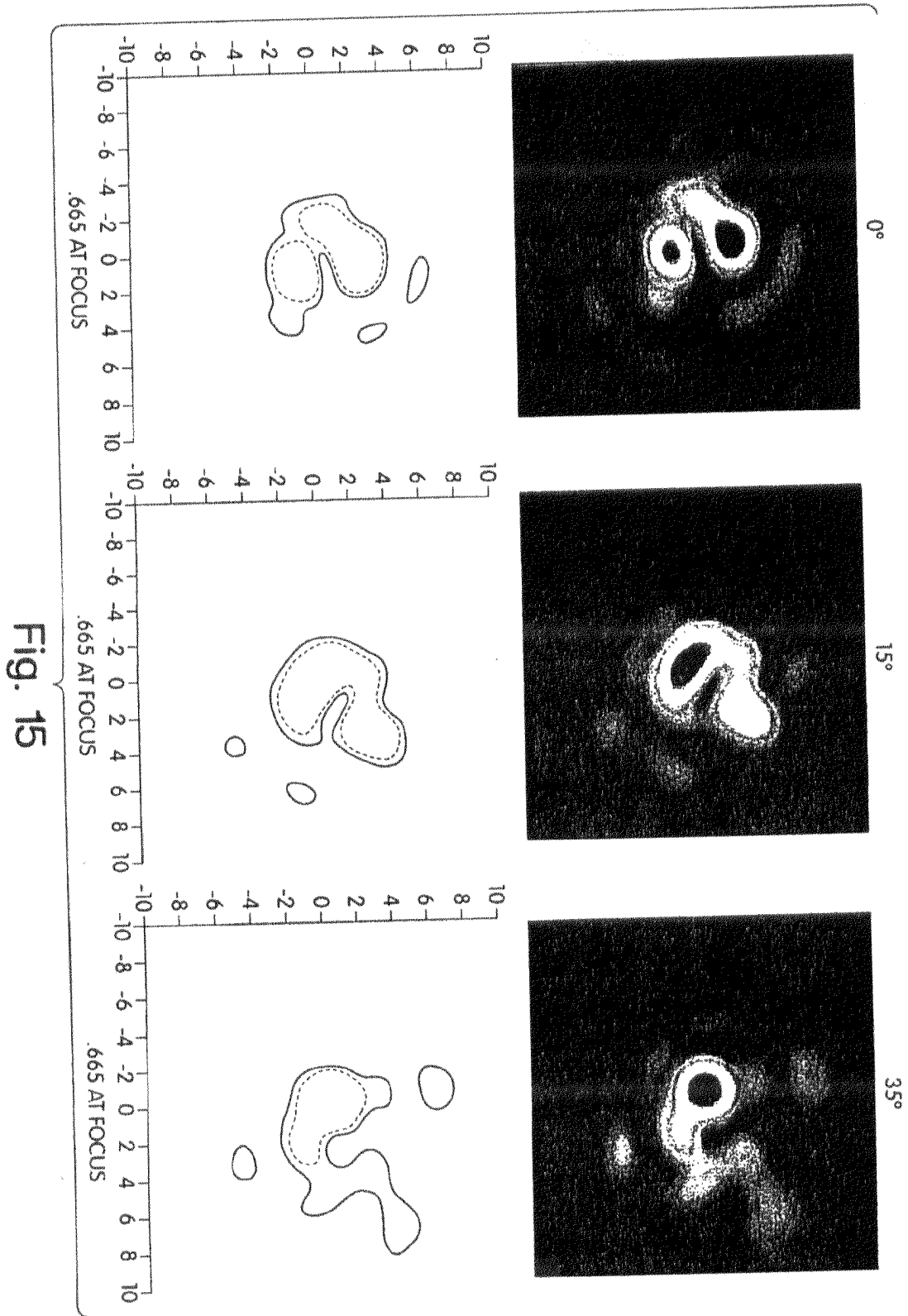


Fig. 14B



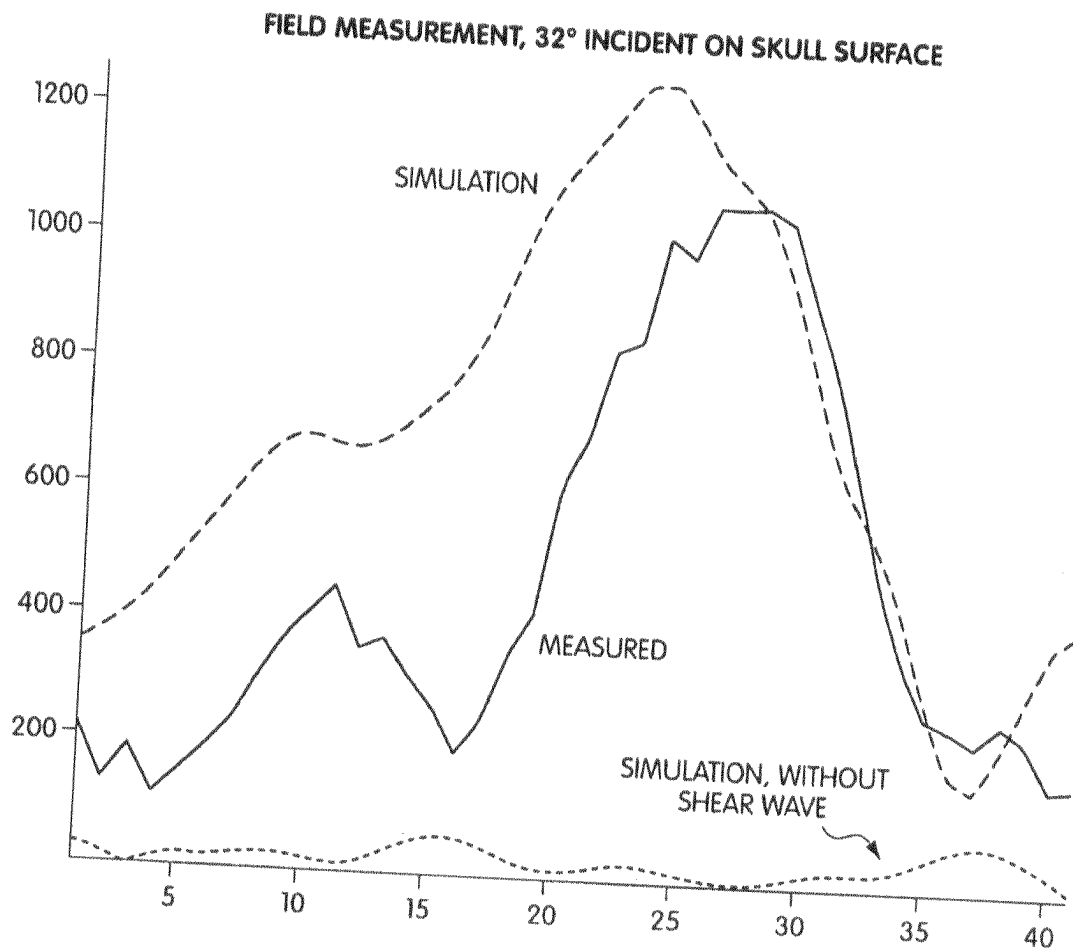


Fig. 16

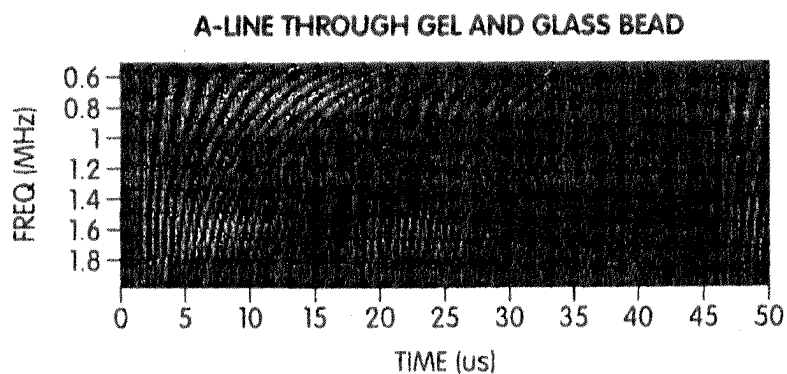


Fig. 17A

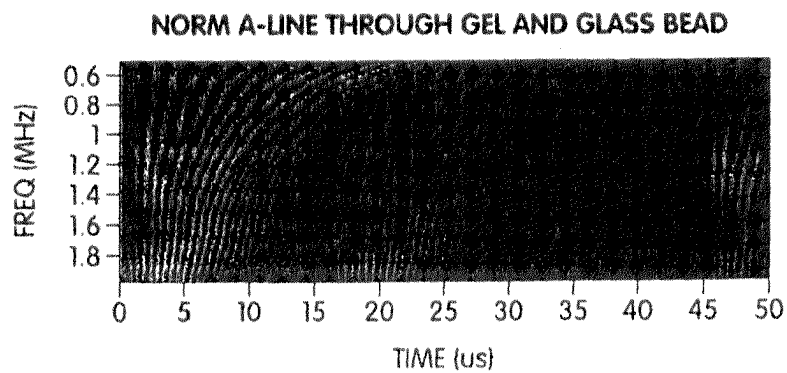


Fig. 17B

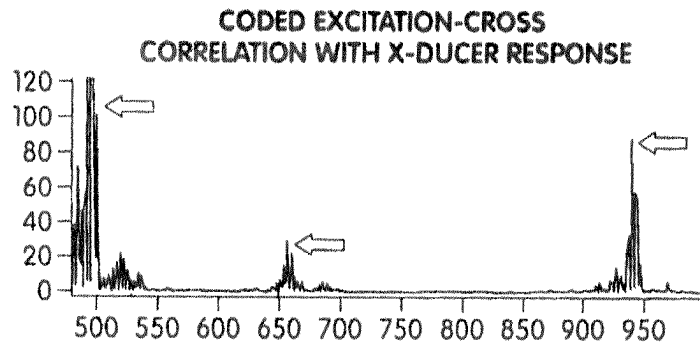


Fig. 18A

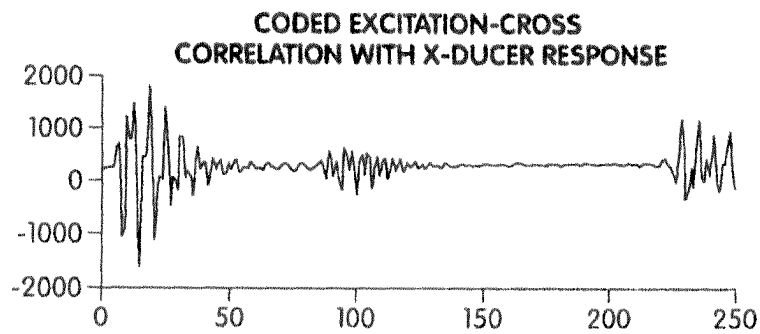


Fig. 18B

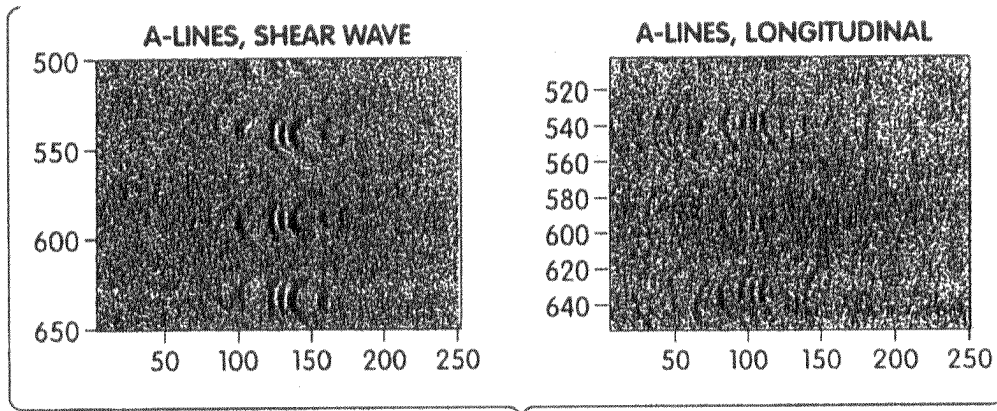


Fig. 19

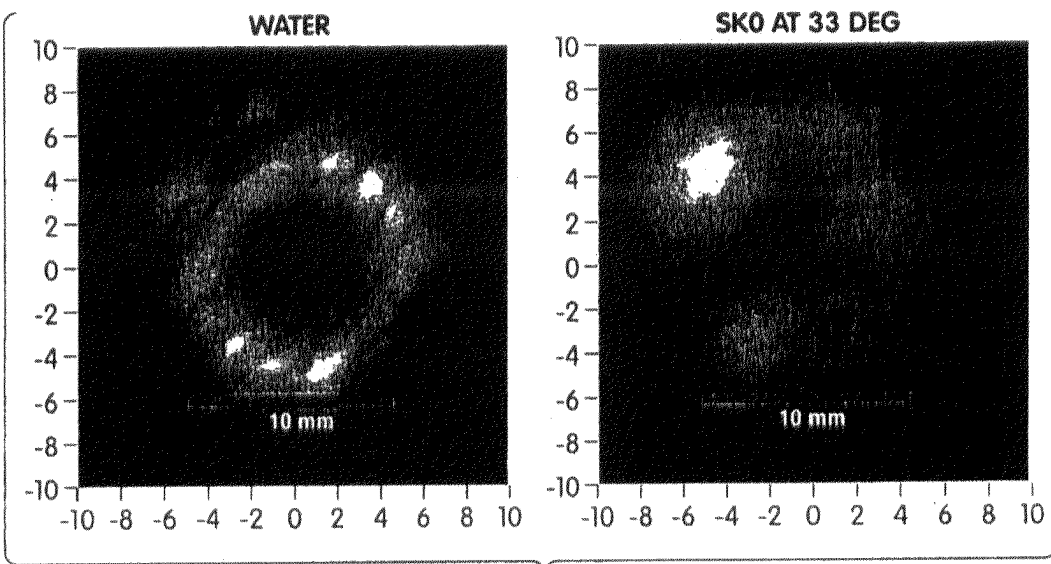


Fig. 20



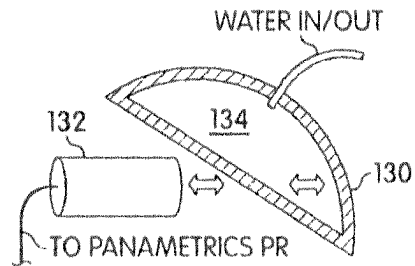
SHEAR IMAGING THROUGH PHANTOM  
AT 1 MHz

Fig. 21

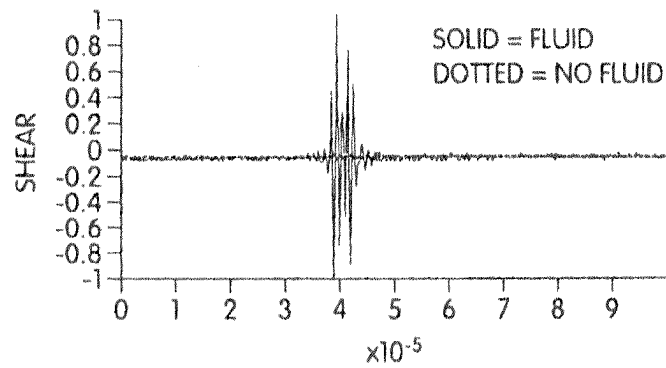


Fig. 22A

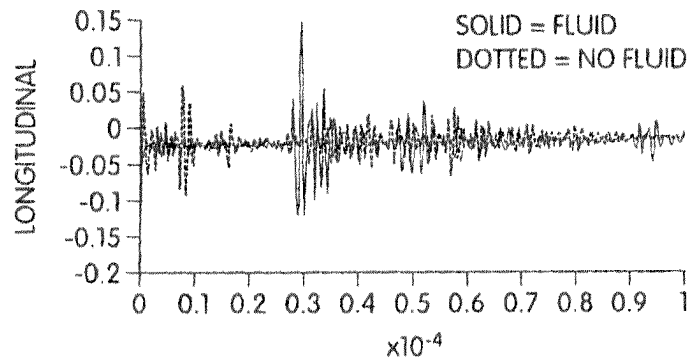
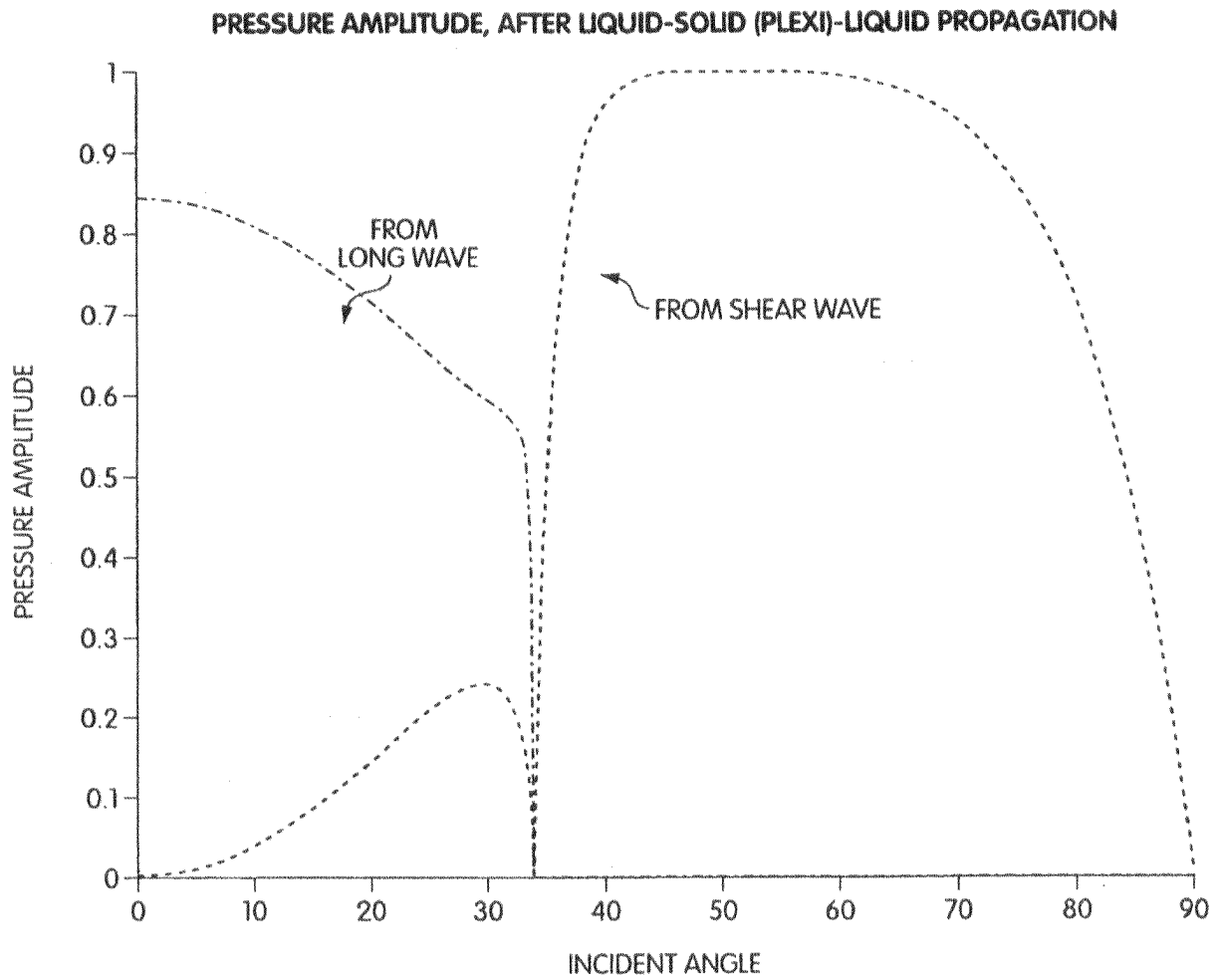


Fig. 22B

**Fig. 23**

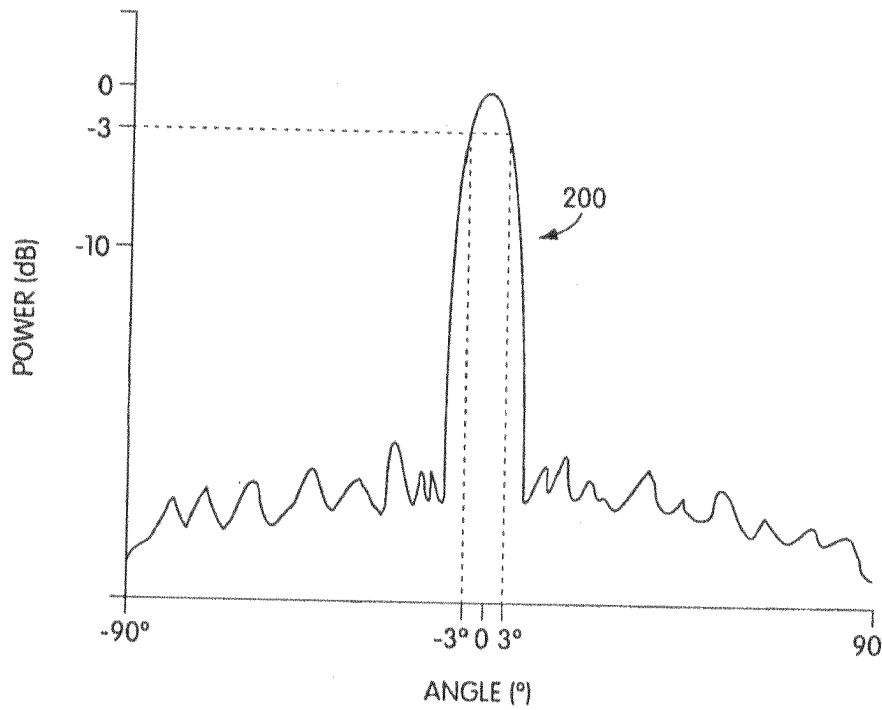


Fig. 24

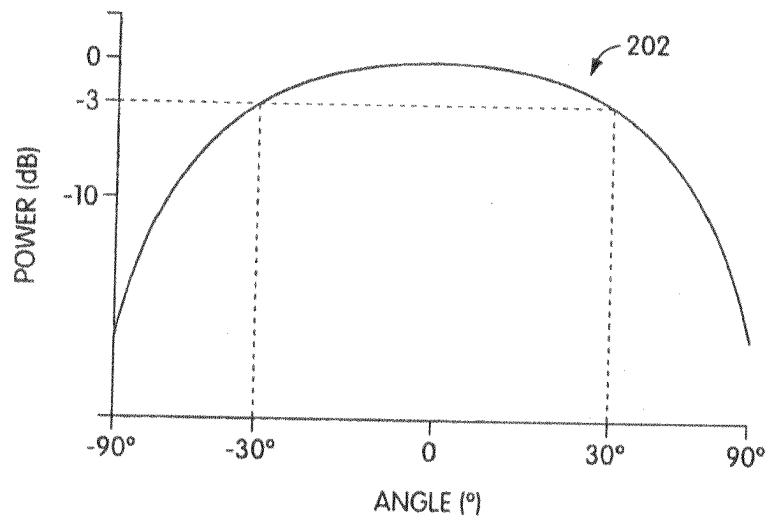


Fig. 25

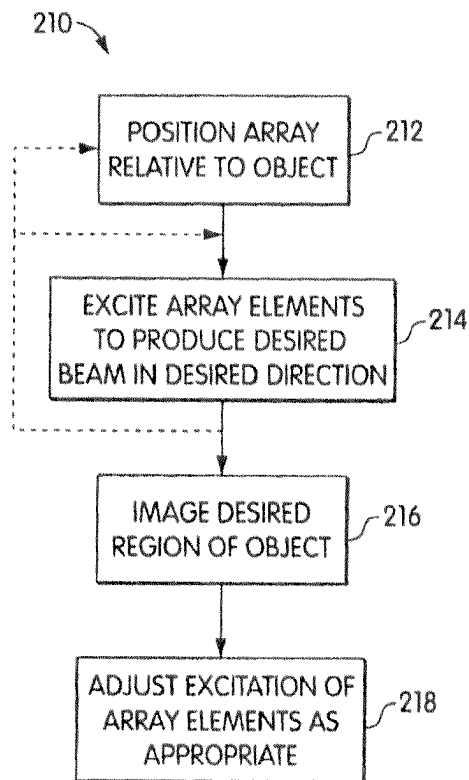


Fig. 26